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A Prototype Distributed Object-Oriented Architecture for Image-Based Automatic Laser Alignment

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Abstract

We have constructed a prototype system for image-based automatic alignment of the NIF in order to demonstrate the principles of object-oriented programming in Ada95 and to demonstrate distributed computer controls using CORBA communication services. This prototype begins to address important issues for the development of a control system for the NIF, in addition to providing a platform for evaluation of alignment devices and concepts.

The computer control system for the NIF must be designed to meet several significant challenges. First and foremost, it must manage the size and complexity of the machine: the NIF will contain over 30,000 control points, controlled by several hundred computers running several hundred thousand lines of software. Furthermore, the control system must be designed in anticipation of the long lifetime of the facility: over the course of thirty years, every computer in the system will be replaced at least once, and specific controls and diagnostics will come and go . The design of the control system should facilitate this evolution.

The requirements of the alignment system illustrates the complexity of the NIF. The system must provide computerized controls for more than 15,000 motors and other devices. The automatic alignment subsystem must adjust 5,000 video sensor-based loops before each NIF shot. Ten automatic alignment front-end processors (FEPs) communicate with more than 100 alignment controllers to accomplish the task in less than 30 minutes.

We are applying object-oriented design and programming in Ada95 to address the issues of complexity, reliability, and maintainability of the software system. Ada is known to reduce cost and risk in large software projects, to be highly reliable, and to facilitate development by a large software team. The new Ada95 standard fully supports the object-oriented paradigm, including encapsulation and inheritance, features which increase the reliability and maintainability and reduce the size and cost of software.

Complexity can be further reduced by a commercial tool which facilitates communication between components of a distributed system. The two major standards applicable to the NIF are Distributed Computing Environment (DCE) and Common Object Request Brokering Architecture (CORBA). The CORBA standard, which enables transparent communication between distributed objects in an object-oriented system, was selected for detailed evaluation.

A prototype system for image-based automatic laser alignment has been developed to evaluate and gain experience with these technologies, as well as to ultimately assist in estimation of speed and accuracy of automatic alignment for the NIF. For the prototype, two VMEbus-based FEPs were assembled, one for alignment device control and one for image acquisition and processing. Each contains a SPARC host processor card, and each communicates using CORBA.

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The prototype alignment control FEP contains a six-axis stepper motor controller and a digital I/O card for control of binary devices, such as solenoids. The processor runs object-oriented server software, written in Ada95, which allows remote clients using CORBA to define and control motorized and binary devices. The software supports control of individual motors, motorized aggregates up to four axes, and matrix translation to mitigate the effects of cross-coupling between pointing and centering adjustments. This is the first software application for device control using CORBA and Ada95.

The automatic alignment FEP prototype contains a high-performance image acquisition and blob analysis system. This hardware acquires images from a CCD camera, digitizes them, and identifies blobs in the images which meet programmable criteria for size and brightness. In the automatic alignment application, an image is acquired from a reference light source, the blob corresponding to reference spot located, and its centroid noted. Then a beam image is similarly acquired. The difference between the two centroids determines the movement command which is sent using CORBA to a motorized device controlled by the other FEP. This procedure is iterated until the centroid is within one pixel of the reference image location.

This prototype system is being used to demonstrate pointing and centering on the simulated NIF beamline that has been constructed in the NIF Alignment Concepts Lab. The system demonstrates the principles of object-oriented programming in Ada95 and the use of CORBA for small-scale distributed control. The application of CORBA may be trivially extended to a larger-scale distributed system, and preliminary simulations indicate that its performance will be adequate to meet the needs of the NIF control system.